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(54) TRACKING MOUNTS FOR CELESTIAL RAY DETECTING DEVICES

(71) I, ELIHU HASSEL MCMAHON, a citizen of the United States of America, of 1870 Schieffelin Avenue, Bronx, New York 10466, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present application pertains to tracking mounts for celestial ray detecting devices which permit tracking of heavenly bodies and celestial sources of various rays in virtually any position in the sky during rotation of the earth.

The mounting is suitable for any celestial ray detecting device including optical telescopes, radio telescopes, spectrophotometers, telescopic cameras and the like, whether large or small. For purposes of simplicity, the following description utilizes optical telescopes as a typical ray detecting device, it being understood that the invention pertains to the mounting and not the particular device mounted thereon.

Common to all telescope mountings used for serious observational work is the presence of two axes. In the most common type of mounting, the equatorial mounting, the assembly rides on a polar or right ascension axis which is aligned in a position parallel to the axis of rotation of the earth and a declination axis set at a right angle to the polar axis.

For smaller and medium size telescopes, perhaps the most common form of mounting is the German mounting in which the bearings for the declination assembly are attached outboard of the upper bearing of the polar axis assembly and the telescope is, in turn, attached outboard of the declination axis bearing with a counterweight mounted at the opposite end of the declination shaft so as to maintain balance in all positions of rotation about the polar axis. While this type of mounting has the advantage of being fairly light, it suffers from the disadvantage that large mechanical stresses are placed on the shafts. It is therefore necessary to make the shafts sufficiently strong to resist vibration and to place the two bearings fairly well apart to ensure stability.

A second mounting assembly which eliminates the need for the counterweight and the heavy declination axis is represented by the fork mounting. In the fork mounting, the polar axis is similar to that in the German mount but the telescope is carried between the declination axis bearings in a fork through which it is swung to gain complete accessibility to the sky. Although the counter-weight and heavy declination shaft have been eliminated, the fork must be of a massive structure thereby requiring a very substantial polar axis assembly to support the load. Moreover this type of mounting is not suitable for refracting telescopes or classical cassegrains since the eye piece becomes inaccessible when the telescope is tracking in the polar regions

A third mounting, commonly known as the English mounting, carries the telescope inboard of both the declination and polar bearing in a large frame in which the telescope swings and which, in turn, rotates about the polar axis to provide right ascension. This type of construction is of great advantage in the use of large telescopes since it minimizes the suspended weight and the stresses caused by that weight. The basic disadvantage of the English mounting is that the polar regions are not visible, a serious enough drawback to have inspired two modifications: the modified English mounting in which the frame is replaced by a suspended column so that the telescope is carried inboard of the polar axis bearing but outboard of the declination axis bearings, the reverse of the fork mounting, and the horseshoe mounting

having a crescent shaped upper polar axis bearing which permits access to the polar regions. The modified English mounting, although quite commonly used, has the disadvantage that a counterweight is required, as in the German mounting, while the horseshoe mounting, one of the most satisfactory forms, presents significant engineering problems.

The first objective of the present invention is to provide a telescope or similar ray detecting device mounting assembly which avoids the various problems heretofore encountered with the above described and other mountings.

A further object in conjunction with the preceding object is to provide a mounting assembly which permits tracking in all regions of the observable sky.

A further objective of the present invention is to provide a mounting assembly in which the centre of gravity of the telescope or ray detecting device can be disposed directly over the support throughout operation of the telescope and regardless of its positioning.

According to the invention, there is provided a tracking mount for a celestial ray detecting device comprising

(a) a base;

(b) a support member rotatably mounted on the base for rotation about a vertical axis;

(c) a rotatable plate assembly mounted on the base adapted so as to assume a position coplanar with the equator of the earth and to be rotatable within that plane about a point lying in the vertical axis of the support member;

(d) an equatorial tracking arm pivotably mounted on the support member along an axis perpendicular to the vertical axis of the support member;

(e) at least one following rod, said following rod pivotably mounted at one end to the equatorial tracking arm and pivotably mounted at its other end to the rotatable plate so as to maintain the equatorial tracking arm in a position parallel to the radius defined within the plane of the rotatable plate by the point of mounting of the following rod;

(f) a declination bearing on the equatorial tracking arm;

(g) a ray detecting device cradle having a shaft riding in the declination bearing, the cradle rotating coaxially through its shaft with the equatorial tracking arm, said cradle being adapted to assume a given declination angle relative to the equatorial tracking arm and thereafter maintain that angle during rotation of the support member about its vertical axis.

In the accompanying drawings:—

Figure 1 is a side elevation of one embodiment of the present invention, showing the telescope being raised from base line to a line b, this positioning corresponding to azimuth at a latitude of (90° — arc *ab*);

Figure 2 is a front elevation of the embodiment depicted in Figure 1, (the telescope being shown aligned along *a* in Figure 1);

Figure 3 is a detailed perspective of a second embodiment of the present invention depicting, in addition to the equatorial plate assembly and associated mechanism, a precession carriage assembly serving as the cradle for the telescope;

Figure 4 is a partial cross-section in detail of the equatorial tracking arm shown in Figures 1, 2 and 3;

Figure 5 is a cross-section of the double bearing assembly through which the telescope's cradle is connected to the equatorial tracking arm;

Figure 6 is a top elevation of one quadrant of the rotatable equatorial plate assembly;

Figure 7 is a section of the entire equatorial plate assembly, one quadrant of which is shown in Figure 6, taken along lines 7—7′ in Figure 6;

Figure 8 is a section of quadrant of the equatorial plate shown in Figure 6 and taken along line 8—8′;

Figure 9 is a top elevation of a second embodiment of a telescope cradle utilizing the precession carriage.

With specific reference to Figures 1 and 2, there is shown a mount having a base 21 which firmly rests upon the ground or a suitable foundation. Rotatably mounted on this base is a support member 22 riding upon a suitable bearing 23 so as to be freely rotatable about a vertical axis, relative to the earth, of base 21. Although not shown, the Figures 1 and 2, the rotation of support member 22 relative to base 21 may be controlled by a suitable clock mechanism so as to automatically compensate for the rotation of the earth.

As shown in greater detail in Figures 3, 6, 7 and 8, a plate assembly comprising an annular member 24 is rotatably mounted upon a track 25 so as to be rotatable within the plane of track 25, track 25 in turn being pivotally mounted to base 21 through bearing 26. Through adjustment gear means 27, the entire plate assembly is adjusted to a plane corresponding to the equatorial plane of the earth. Hence in Figure 3, the equatorial plane is set at an angle to the horizontal corresponding to the complement of the latitude at which the assembly is employed. While Figures 1, 2, 3 and 6, 7 and 8 depict an embodiment in which the angle of the plate assembly is variable, it is apparent that for large, permanently installed installations, the equatorial plate assembly may be rigidly

fixed to base 21 at the appropriate angle for the latitude of installation.

The two basic components of the rotatable plate assembly, track 25 rotatably mounted on base 21 and annular member 24 rotatably mounted on track 25, are so arranged that annular member 24 will rotate within the plane defined by the setting of track 25 relative to base 21. The centre of rotation of annular member 24 lies at a point on the vertical axis of rotation of support member 22, the angle defined by the axis of rotation of support member 22 and the axis of rotation of annular member 24 corresponding to the latitude of use of the mounting assembly.

Returning to Figures 1—4, an equatorial tracking arm 28 is pivotably mounted on support member 22, the axis of rotation of the tracking arm 28 being perpendicular to the vertical axis of support member 22 and base 21. Connecting the equatorial tracking arm 28 and the annular member 24 of the rotatable plate assembly is at least one and preferably two following rods 29. Following rod 29 is pivotably mounted at one end to the equatorial tracking arm at bearing 30 (see Figure 4) and pivotably mounted at the other end to annular member 24 of the rotatable plate assembly through joint 31 (see Figures 6 and 7). Ideally joint 31 is a ball and socket joint which permits the assumption of a variety of angles by the rotatable plate assembly relative to the base and at the same time, rotation of annular member 24 about track 25. In its preferred embodiment, the tracking assembly will utilize two following rods 29, the rods being pivotably mounted equidistant from the centre of and on a diameter within the plane of the rotatable plate. The opposite ends of the following rods are then pivotably mounted on the equatorial tracking arm at opposing points equidistant from the centre of its rotation. As a result of the parallelogrammatical mounting of following rods 29, equatorial tracking arm 28 and the rotatable plate, the equatorial tracking arm is maintained in a position parallel to the radius defined within the plane of the rotatable plate assembly by the point of mounting of the following rod during rotation of support member 22 about base 21.

Equatorial tracking arm 28 is rotatably mounted upon support member 22 through a double bearing, shown in greater detail in Figure 4 and particularly Figure 5. Thus support member 22 carries a declination bearing 32 which is rotatably mounted therein and is an extension of tracking arm 28. Within the declination bearing 32 is shaft 33 of ray detecting device cradle 35, cradle 35 thus being rotatably mounted within declination bearing 32 of the equatorial arm through shaft 33. Shaft 33 is rotatably positioned relative to declination bearing 32, and thus tracking arm 28, through suitable engagement means such as worm gear 34. Cradle 35 thus assumes a given declination angle relative to equatorial tracking arm 28 and thereafter maintains that angle, relative to the equatorial tracking arm, during the movement of the tracking arm as it follows annular member 24 of the rotatable plate assembly in the course of rotation of support member 22 about its vertical axis and the concurrent rotation of annular member 24 about track 25. Consequently, once the rotatable plate assembly is placed in a position coplanar with the earth's equator and cradle 35 is raised above azimuth to the appropriate declination angle through gear means 34 relative to tracking arm 28 (which by virtue of the adjustments to plate 24 has already assumed a position parallel to the plane of earth's equator), and support member 22 is rotated about base 21, cradle 35 and the associated ray detecting device attached thereto will move in right ascension in following the ecliptic of the given body.

In its simplest embodiment, the telescope or other ray detecting device is directly mounted to shaft 33 riding in declination bearing 32 through a suitable telescope cradle 35 so that the angle assumed by the telescope relative to tracking arm 28 corresponds to that assumed by cradle 35 upon adjustment of gear means 34. A significant advantage of this assembly is that the telescope can be mounted on the cradle so that its centre of gravity is directly over the support and base and remains there in all positions.

A more versatile, albeit more complex, assembly is depicted in Figures 3 and 9 in which cradle 35 forms a precession carriage which, in turn, is adapted to receive the ray detecting device. In this embodiment, the cradle comprises an annular track 35 having shaft members 33 diametrically disposed on the outside of the annular track and adapted to ride in the declination bearing 32, at least one bearing support 36 disposed within annular track 35 and adapted for coplanar rotation within it and a precession carriage 37 adapted to receive the ray detecting device and pivotably mounted on bearing support 36 along an axis lying in the plane of the annular track. The ray detecting device riding on carriage 37 can be angularly adjusted through its longitudinal axis relative to the plane of annular track 35. The bearing support 36 may be made up of a series of trolleys, as shown in Figure 9, or may be a concentric annular member 38, as shown in Figure 3, which revolves within the annular member 35.

Driving means 39 may be provided either

on the annular track 35 or on the bearing support 36 in order to rotate the bearing support within the plane of annular track 35. In addition, driving means 40 may be provided in order to rotate precession carriage 37 within bearing support 36.

The embodiment depicted in Figures 3 and 9 can be utilized with both large and small telescopes. It is particularly suited however for extremely large telescopes in that driving means 39 and 40 can be coordinated with rotation of the support member and the various angles assumed by the equatorial tracking arm during the course of this rotation. Thus in a preferred embodiment, driving means 39 are coordinated with rotation of the support member 22 so that the axis of rotation of carriage 37 is always parallel to the diameter lying within the plane of rotatable member 24 on which the support members are mounted. Utilizing this principle, it will be observed that if the rotatable plate assembly is placed coplanar with the equatorial plane and the telescope is rotated on shaft 37 so as to assume the proper declination angle relative to the plane of the annular track 35 (which is held perpendicular to equatorial tracking arm 28 and the rotatable plate assembly), subsequent rotation of support member 36 within track 35 so as to maintain the axis of shaft 37 in a position parallel to the plane of the rotatable plate assembly will define an oscillating movement during one full rotation of the rotatable plate assembly and support.

Figure 9 also depicts a second and alternative embodiment of the double bearing shown in detail in Figure 5. In this second embodiment, in place of a concentric bearing, tracking arm 28 is rotatably mounted on support member 22 and declination bearing 32 is in turn mounted on tracking arm 28 with shaft 33 riding in declination bearing 32.

WHAT I CLAIM IS:—

1. A tracking mount for a celestial ray detecting device comprising

(a) a base;

(b) a support member rotatably mounted on the base for rotation about a vertical axis;

(c) a rotatable plate assembly mounted on the base and adapted so as to assume a position coplanar with the equator of the earth and to be rotatable within that plane about a point lying in the vertical axis of the support member;

(d) an equatorial tracking arm pivotably mounted on the support member along an axis perpendicular to the vertical axis of the support member;

(e) at least one following rod, said following rod pivotably mounted at one end to the equatorial tracking arm and pivotably mounted at its other end to the rotatable plate so as to maintain the equatorial tracking arm in a position parallel to the radius defined within the plane of the rotatable plate by the point of mounting of the following rod;

(f) a declination bearing on the equatorial tracking arm;

(g) a ray detecting device cradle having a shaft riding in the declination bearing, the cradle rotating coaxially through its shaft with the equatorial tracking arm, said cradle being adapted to assume a given declination angle relative to the equatorial tracking arm and thereafter maintain that angle during rotation of the support member about its vertical axis.

2. A tracking mount according to claim 1 having two following rods pivotably mounted equidistant from the center of and on the diameter within the plane of the rotatable plate assembly.

3. A tracking mount according to claim 1 wherein the rotatable plate assembly is planarly fixed relative to the vertical axis of the support member.

4. A tracking mount according to claim 1 wherein the rotatable plate assembly is pivotably mounted on the base so as to be adjustable at any given latitude to a position coplanar with the equator.

5. A tracking mount according to claim 1 wherein the rotatable plate assembly comprises a track pivotably mounted on the base and an annular member rotatably mounted on said track, said plate assembly being adjustable through gear means so as to assume a position coplanar with the equator of the earth at the latitude of use, one end of each of two following rods is pivotably mounted on the equatorial tracking arm at opposing points equidistant from the centre of rotation of the tracking arm, the other end of each of the following rods is mounted through a ball and socket joint to the annular member of the rotatable plate assembly at a point equidistant from the center of and in a common diameter within the plane of the rotatable plate assembly, and said cradle is mounted through its shaft to the declination bearing of the equatorial tracking arm through gear means whereby the ray detecting device riding in said cradle can be adjusted to a given declination angle relative to the equatorial tracking arm and thereafter maintained at that angle during rotation of the support member about its vertical axis.

6. A tracking mount according to claim 1 wherein the ray detecting device cradle comprises

(i) an annular track;

(ii) shaft members diametrically disposed on the outside of the annular track and adapted to ride in said declination bearing;

(iii) at least one bearing support disposed within said annular track and adapted for coplanar rotation within the annular track;

(iv) a precession carriage adapted to receive a ray detecting device and pivotably mounted on said bearing support along an axis lying in the plane of the annular track whereby the ray detecting device riding on said carriage can be angularly adjusted through its longitudinal axis relative to the plane of the annular track.

7. A tracking mount according to claim 6 wherein the bearing support is annular and disposed within said annular track for coplanar rotation.

8. A tracking mount according to claim 6 wherein said bearing support comprises at least two trolleys disposed equi-angularly within said annular track for coplanar rotation.

9. A tracking mount according to claim 6 including means to coordinate the rotation of the bearing support within the annular track with the rotation of the support member whereby the axis of rotation of the precession cradle is maintained parallel to a diameter of the rotating plate.

10. A tracking mount according to claim 1 wherein the rotatable plate assembly is pivotably mounted on the base, said plate being adjustable through a gear means so as to assume a position coplanar with the equator of the earth at the latitude of use, one end of each of two following rods is pivotably mounted on the equatorial tracking arm at opposing points equidistant from the center of rotation of the tracking arm, the other end of each of the following rods is mounted through a ball and socket joint to the rotatable plate assembly at a point equidistant from the center of and in a common diameter within the plane of the rotatable plate, and said cradle comprises

(i) an annular track;

(ii) shaft members diametrically disposed on the outside of the annular track and mounted to the declination bearing of the equatorial tracking arm through a worm gear whereby said cradle can be adjusted to a given declination angle relative to the equatorial tracking arm and thereafter maintained at that angle during rotation of the support member about its vertical axis;

(iii) at least one bearing support disposed within said annular track and adapted for coplanar rotation within the annular track;

(iv) a precession carriage adapted to receive a ray detecting device and pivotably mounted on said bearing support along an axis lying in the plane of the annular track whereby the ray detecting device riding on said carriage can be angularly adjusted through its longitudinal axis relative to the plane of the annular track.

11. A tracking mount for a celestial ray detecting device, substantially as herein described with reference to the accompanying drawings.

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1406077 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

FIG. 1

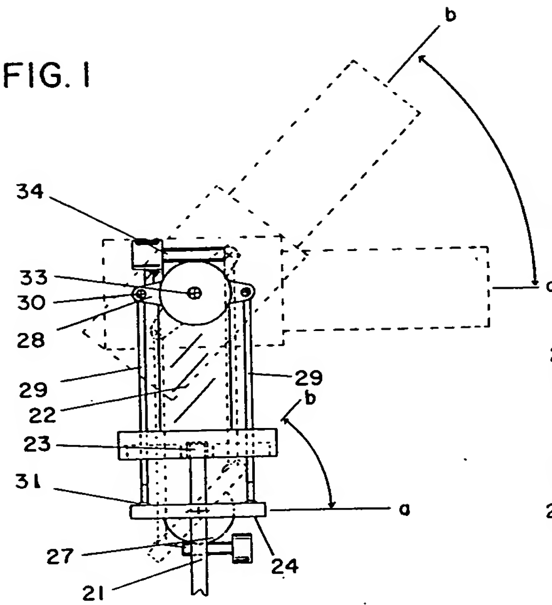

FIG. 2

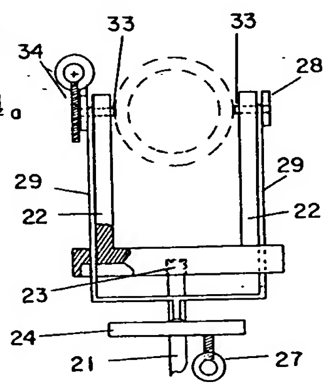

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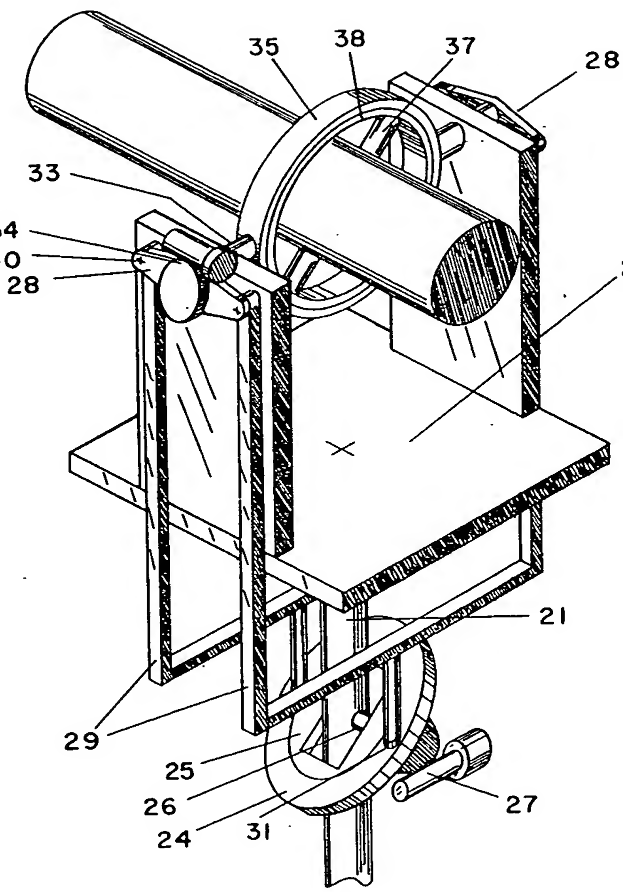
FIG. 3



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1406077 COMPLETE SPECIFICATION

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Sheet 3

FIG. 4

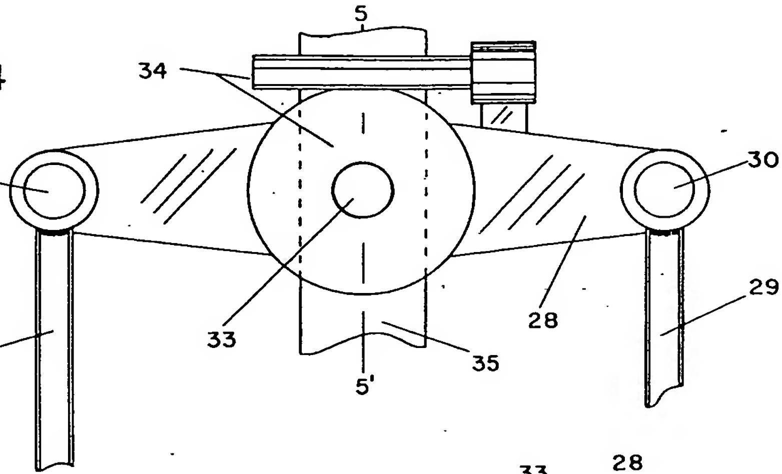

FIG. 5

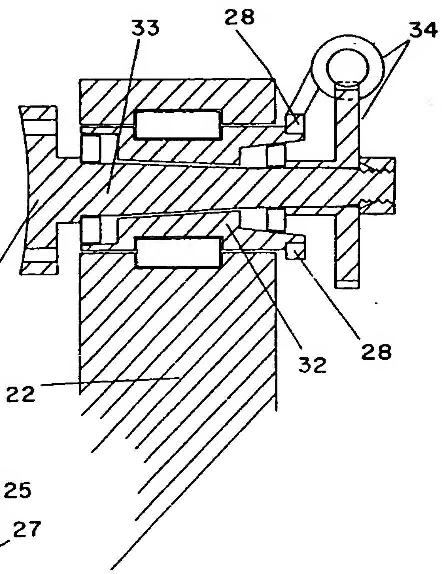

FIG. 6

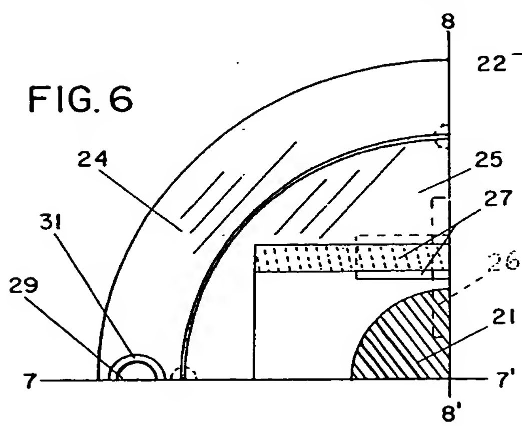

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FIG. 9

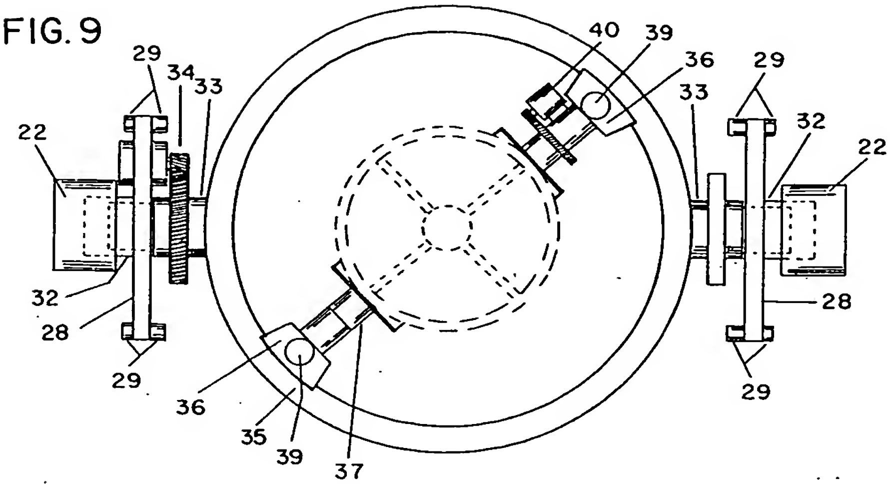


FIG. 8

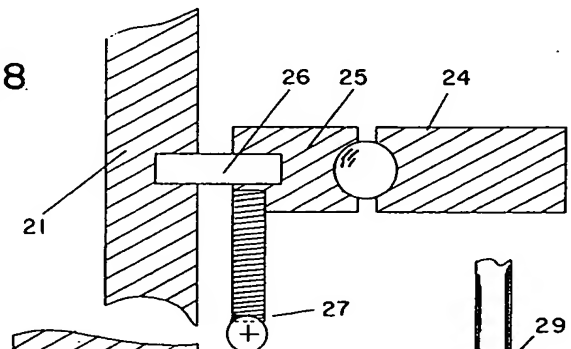
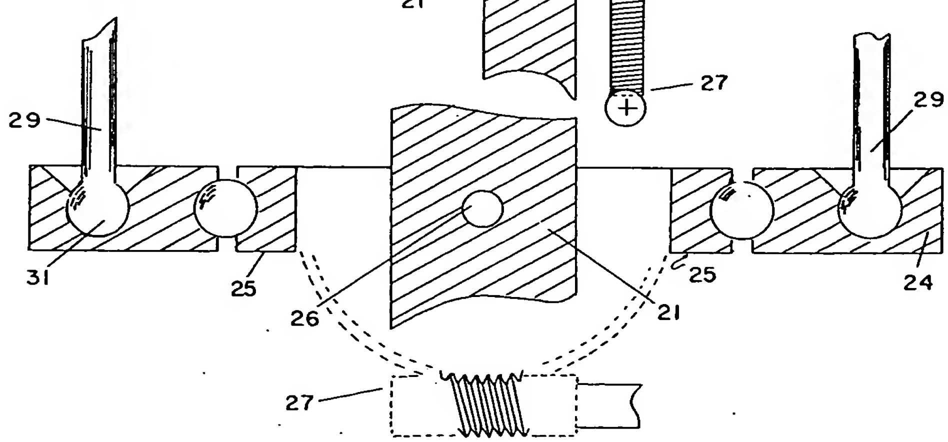


FIG. 7



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